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The Monterey and Pacific Grove Lighting Plant.

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THE JOURNAL OF ELECTRICITY.

VOLUME VII. SAN FRANCISCO, MARCH, 1899. NUMBER 3.

The Monterey and Pacific Grove Lighting Plant.

BY HARRY J. BEAN, A. B., E. E.

CALIFORNIA probably contains as diversified an assortment of electric lighting and power plants as is to be found in any state in the union. It has electric transmission power houses that are, in many respects, without equal the world over; it has central stations that are thoroughly metropolitan in every sense of the word; it has steam-driven electric lighting plants operated from boilers burning coal, wood, sawdust, oil, and natural gas; it has water power plants driven under heads varying from six feet to fourteen hundred feet, and it has even projected—the word is used advisedly—electric stations that are to be operated by wave power. Much has been written of all these plants, but, singularly, the type of station most common throughout California, has been overlooked by descriptive writers, and as in it is represented a material factor of the electrical industry of the Golden State, the oversight has wrought an injustice to a very important branch of electric lighting. The similarity in the features of construction and operation of these smaller stations is generally marked, hence but a single one will be described, namely, that of the towns of Monterey and Pacific Grove.

Monterey and Pacific Grove, which are two and one-half miles apart, have only one lighting company between them. This company started to furnish Monterey with lights in May, 1890, and it was not until the early part of 1894 that it established the alternating system by which Pacific Grove is lighted. The power house is centrally located in Monterey city, and is a rough frame building about 60 feet in length and 30 feet in width, with a store front, gable roof, and no floor. The relative positions of the machines, switchboards, boiler room, etc., are shown in Figure 1. The boiler is a two-sheet, fire tube boiler, having a rated capacity of 60 horse-power, the pressure of steam maintained being 90 pounds per square inch. When the engineer wishes to have the steam pressure rise rapidly he sprinkles a little water on the ashes in the ash pit. The pressure gage is plainly visible from where the engineer sits through a hole cut in the door. He regulates the steam pressure, without rising from his seat, by means of what he has termed the "lazy man's damper." This damper is shown in its relative position in Figure 1 and in detail in Figure 2. The pipe enclosing the rod is sunk a little below the floor level so as to be out of the way. The trigger comes out through a slot in the floor near the barrel chair, and by moving the trigger one way or the other the ash pit or draft door can be opened or closed. The engineer moves the trigger with his foot and the ash pit door is furnished with a spring which tends to keep it open.

The boiler room is a room by itself as shown in the first figure. Pine wood, which is in four-foot lengths, is used for fuel, and it is far superior to redwood for steaming purposes as is shown by the fact that pine is used when redwood only costs about two-thirds as much. The engine is a single expansion engine having a rated capacity of 50 horse-power. There are two fly-wheels, one of which contains a centrifugal governor. The length of stroke is twelve inches, and the speed 255 revolutions per minute. A naked steam pipe connects the engine and boiler. The plant is supplied with a small feed pump but it is never used as the head of water from the street main is such as to give 110 pounds pressure per square inch.

Figure 3 shows the oil filter used and in it the oil is filtered through sawdust and a little waste.

The station contains two direct current machines and one alternator, the relative positions of which are shown in Figure 1. The alternator and one direct current generator are belted to one of the fly-wheels, and the other direct current generator is belted to the other fly-wheel, the alternator belt being run on top of the direct current machine's belt, or "tandem."

The alternator is an old T. H. ten-pole machine, originally wound for 1040 volts, but afterward rewound for 2080 volts, but after rewinding it failed to develop 2080 volts until the speed was increased by 200 revolutions per minute. It is now run at a speed of 1800 revolutions per minute, and its capacity is 300 lights. The bearings are oiled by means of feed cups. The two Edison bipolar direct current machines are run at 1600 revolutions per minute and the capacity of each is 250 lights, the voltage at the brushes being 110. The bearings are self-oiling. The lubricant used on the commutator is a patented compound, and there is no sparking at the brushes. The engines and generators are all set upon concrete foundations.

In Figure 4 and Figure 5 are shown respectively the direct current and alternating switchboards, with their connections to the mains and generators. The switchboards are 8 feet square for the direct current, and 9 feet by 4 feet for the alternating current. They are both made of tongued and grooved redwood boards, 5 inches in width

and ¾ of an inch in thickness. The direct current board is varnished and the alternating current board is painted white. They are each held about two feet from the ground

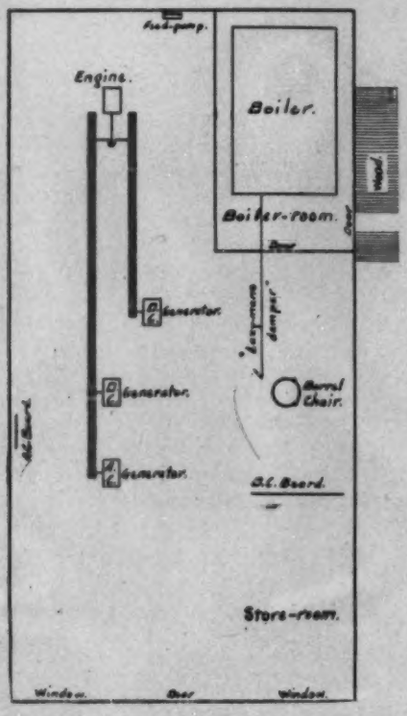

FIGURE 1.

by means of posts set into the ground. The relative positions of these switchboards are shown in Figure 1.

All direct current distribution is by the Edison three-wire system, 110-volt lamps being used on a side. The scheme of alternating distribution appears diagrammatically in Figure 6, from which it will be seen that the primary delivers 2080 volts, either to a single transformer or to two 1040-volt transformers in series. Incandescent service on the alternating circuit is rendered at 105 volts, both by the two-wire and the three-wire system, according to the number of lights. There are six transformers, such as A in Figure 6, between Monterey and Pacific Grove distributing lights by the two-wire system. B, C, and D, in Figure 6, show each two transformers whose primaries are connected in series and whose secondaries are connected to a common or neutral wire between which and the secondary mains the lights are placed, the neutral wire of C being connected to the neutral wire of D. C and D are right across the street from each other in the business center of Pacific Grove. The alternator mains are No. 7 w. p. copper wire and the secondary mains are No. 10 w. p. copper wire.

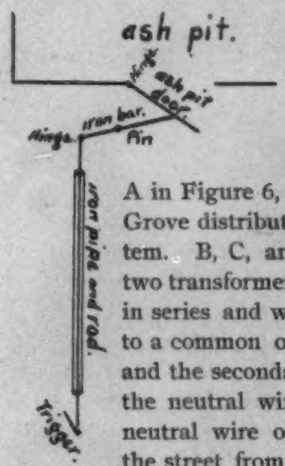

FIGURE 2.

The lightning arresters are screwed up on the front wall of the power house. Figure 7 was drawn on the spot and is a fair representation of the way the connections look. They are all Wurts' lightning arresters, the three large ones being type C and the five small ones style 1383. The company had no lightning arresters until the fall of 1894 when the lightning struck the line and played havoc with the machines. They then put in the three type C arresters, but failed to put in a choke coil by oversight, and the line was struck again in the fall of 1895. The engineer heard the arresters pop and an instant later fire was flying in all directions from the armature. They then put in the five style 1383 arresters and the choke coils. No trouble has been had from lightning since.

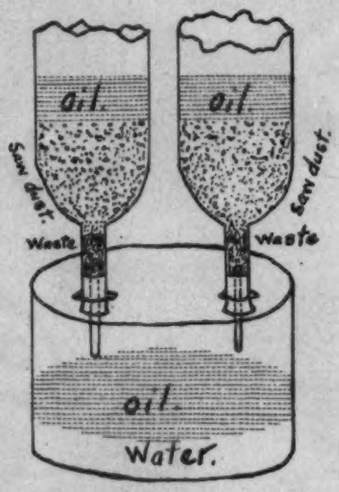

FIGURE 3.

The secondary of all the transformers consists of two separate coils which may be joined in series if desired. One of the six, like A in Figure 6, is a General Electric type H transformer, and the potential transformer at the switchboard is type H. One of its secondary coils is connected to the voltmeter and the other to a lamp. Each coil gives 54 volts. All of the others are the General Electric type F transformers. The transformers shown at C in Figure 6 gave some trouble by water getting into

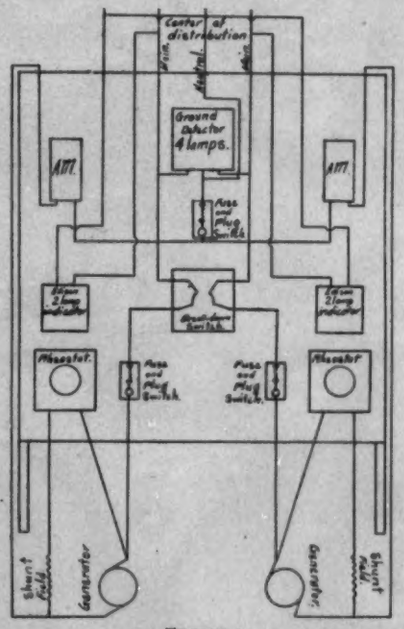

FIGURE 4.

them through the holes for the wires. The water short-circuited the coils and the fire and steam quite startled the good people of the town. The engineer placed a tin hood over these transformers and has had no trouble since of that kind. General Electric primary cut out boxes are

fastened to the cross-arm and the transformers are placed just beneath the cross-arm on the pole. The poles are all 30 feet in length, 10 inches square at the bottom, and 6 inches square at the top. They are placed 5 feet in the ground and 122 feet apart. The top of the pole is peaked so as to form four equilateral triangles. The poles are

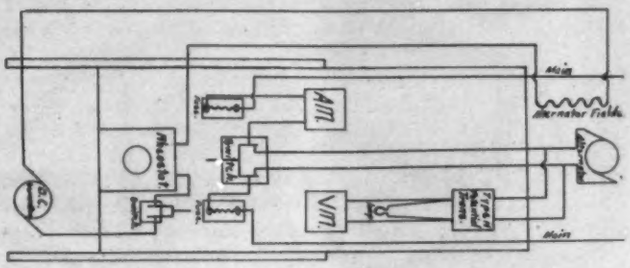

FIGURE 5.

made of redwood. A gain one inch in depth is made about ten inches from the top of the pole to receive the cross-arm. The cross-arm is made of pine four inches square and five feet long. Four holes are bored in the cross-arms for 1½-inch pins. The cross-arm is placed in the gain and bolted to the pole with two ½-inch bolts. The pins are wooden 1½-inch pins, those in Monterey being oak and those in Pacific Grove being locust. The insulators are of the single-petticoat glass type. The cross-arms are always put on the same side of the pole, no matter whether the resulting strain has or has not a normal component to the cross-arm, tending to pull the cross-arm off of the pole. The poles in Pacific Grove are painted white, except six feet from the ground, where they are painted gray and sanded. The rest of the poles are painted red. The transformers are all fifty lighters.

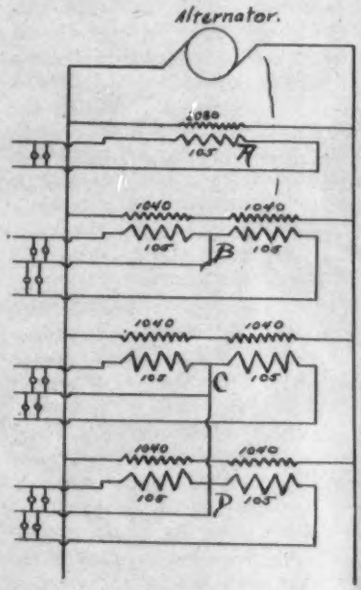

FIGURE 6.

The street lights are of 32 candle-power and the house and store lights are 16 candle-power, all being Edison lamps. The street light hanger, which is made in Monterey, consists of a curved piece of half-inch pipe about four feet in length, on to whose ends are screwed a flange and a reflector. A wire, from the curved part of the pipe to the pole, braces the hanger, the flange being screwed to the pole. The hanger is placed about eight feet from the ground and the reflector is a cone of tin inverted and soldered into another cone of tin which is screwed to the pipe, the lamp being placed at the apex of the cone. The reflector is painted white. The wire is brought down the poles on small porcelain knobs and out along the pipe through clay tubes.

Steam

THE TREND OF CENTRAL STATION DESIGN.*

BY BION J. ARNOLD.

IT has been but little over a decade when the electrical student was told by those who were supposed to be in authority, that to get a reasonable efficiency in electrical machinery, high rotative speed in the moving parts was necessary. While this statement contains an element of truth, it is by no means so important as at first supposed, for our slow speed generators and motors of today are more efficient than many of the high speed machines of that time. Difficulties in the manufacture of heavy electrical machinery and lack of knowledge on the part of the designers of that time were probably the father of the false idea; but be that as it may, the result was to flood the country with electrical plants, consisting of engines, dynamos, pulley shafting and belts, good, bad and indifferent, thrown together in almost any manner. These, however, performed their functions remarkably well under the circumstances, and enabled the youngest branch of the engineering industry to command the brains, energy and capital necessary to revolutionize the transportation and factory methods of our cities and make herself felt in many of the homes of our smaller cities and towns. But since Darwin's law of "the survival of the fittest" applies equally as well in engineering as in natural history, the belts and pulleys are gradually becoming ex-

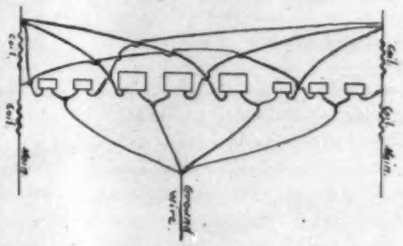

FIGURE 7.

tinct; the engines and generators have left off their prehistoric ear marks and have grown to their responsibilities and to the possession of those elements which make them the bulwarks of electrical industries, the same as the older types of steam engines were to the factories which they drove prior to the advent of electrical transmission. To determine how far this development has gone and its probable tendency in the future, is the subject about to be discussed.

The problem which confronts the power station designer is almost invariably that of the operation of arc lamps, incandescent lamps, and motors for various purposes, with the greatest degree of economy, and with as little expenditure in first cost of plant as possible. This is strictly true of combined lighting and power stations which present the most difficult cases to handle. When, however, the problem is simply one of the development of electrical energy for power purposes only, such as railway work or transmission work, it becomes much simplified. Since the question of the design of a station is interlinked with, and dependent upon the system of distribution adopted, we find ourselves struggling with many of the old questions and some new ones: such as the alternating arc versus the series arc, and the constant potential arc; the polyphase transmission plant versus the direct current; the advisable voltage, either alternating or direct, to adopt for central station work.

While I do not, in this paper, presume to settle these questions, we must necessarily form some idea of their probable solution for general cases, for otherwise we can hardly expect to speculate on "the trend of central station design." The old belted station may be considered obsolete, and we come at once to the general

*Abstract of a paper read before the Northwestern Electrical Association, January 18, 1899.

types which have been recently installed by competent engineers, and which may be considered as embodying the latest ideas of those skilled in this class of work. In all of these stations we find certain main parts which may be considered as accepted practice. Of course there are many belted stations running and doing excellent service, which simply speaks well for the engineers and designers, and more especially the manufacturing companies that installed them in the earlier days.

The points in accepted practice are:

Water tube boilers, capable of carrying high steam pressures. This probably will be disputed somewhat by the advocates of other types of boilers, and with some reason; but it nevertheless has become almost standard to use water tube boilers in modern central stations.

Mechanical stokers, or improved furnaces or grates.

Self-supporting brick or steel stacks, usually steel. A steel stack can be put up for considerably less money than a brick stack, and for all practical purposes it is equally as good, and can be maintained a sufficient number of years to warrant its adoption in almost every case, if properly looked after.

High pressure steam piping is not duplicated, as was formerly thought necessary by engineers, practice having proven that one single steam header can be divided so as to make a plant reliable if the engines are properly located with reference to the boilers and the header. There are few engineers in the country today putting in plants with duplicate systems of piping, unless in buildings where it seems necessary to do it, and on account of the peculiar location of the engines with reference to the boilers. Steam piping costs excessively in a power station, and the less of it put in the better, because there is then less radiating surface to waste heat and fewer parts to keep up. The diameters of the steam heaters now being placed are somewhat decreased, as compared with those installed four or five years ago.

Large compound condensing steam units. It has become accepted practice to install as large engines as practical, on account of the decreased cost per horse-power and the increased economy of a large engine over a small one. They are almost invariably compound engines, where it is possible to condense, and in many cases whether it is possible to condense or not. The tendency toward triple expansion work is not as strong as it was five years ago, it having been determined that for almost all cases a compound engine will get nearly as good economy as a triple expansion engine, and in many cases just as good; it requires less investment, is less costly to maintain, and the difference in economy of the triple expansion over the compound is so slight that it makes it inadvisable to install, except in exceptionally large sizes. On account of the excessive diameters of the low pressure steam cylinders in large compound engines it is the practice to install triple cylinder compound engines; that is to divide the low pressure cylinder into two smaller cylinders, the combined area of the two being equal to the area of the large cylinder of a single compound engine.

Direct connected generators of large capacity. What has been said in general regarding large steam units applies equally as well to electrical generators, because the larger the unit the greater the economy of the combined unit.

To these chief features of design, which have become so generally accepted as to require little or no discussion, there may be added several features which may be justly called "tendencies" or "trends," which have not yet been universally adopted.

Under the first heading comes *Economizers.* Economizers consist of a series of vertical cast iron tubes carrying water within them and around the outside of which the gases pass from the boilers to the smokestack. There is no doubt but that there is economy in the use of an economizer, ranging from five to seven or eight and sometimes as high as ten per cent. In order to get the benefit of an economizer ample draught must be provided. Sometimes an economizer is installed where the draught is poor, the result being no economy and the annihilation of the draught. There is only one solution for this and that is to increase the height of the stack or introduce mechanical draught to realize the benefits of the economizer.

Mechanical draught. Under this head there are two types: induced draught and forced draught. Induced draught is a device which consists of a large fan or fans driven by steam engines or electric motors, which are placed between the economizers and the smokestack; or, if economizers are not used, between the boiler flues and the smokestack, the object being to draw or suck the smoke from the boilers through the fan and deliver it into the stack. The advantages of the forced draught scheme are, first, a lower and less expensive stack can be used; in fact, no stack at all is required except to get the gases above the buildings in the immediate neighborhood of the property. Second, the fires can be handled under any and all conditions. We are all aware that the condition of the atmosphere changes our draught, and in case a stack is no larger than is required, there are days when it is difficult to hold steam, and it becomes necessary to put more boilers into service than would be necessary if a mechanical draught fan were used. Where the economizers can be installed in connection with induced draught, an economy is always effected.

Then there is the forced draught which consists in blowing air under the grates of the boiler and forcing it up through the fire and into the stack, which is supposed to perform the same function that the induced draught does. The objections to it are that inasmuch as it creates pressure in the fire-box, the gases are liable to escape out into the room and make a distasteful fire room. Otherwise, the results accomplished are practically the same as accomplished with forced draught, and it is considerably less expensive to install, and this is its chief advantage.

Cooling devices. Under this head come cooling towers and cooling tables. In most plants in this country there are probably no facilities or natural opportunities for getting water for condensing purposes, and until recently we have thought it was advisable to continue to operate these plants non-condensing. During the past two years there has been a tendency to put in these cooling towers, and when properly put in there is always an economy effected, resulting in a net saving of fifteen per cent. in fuel. A tower consists of a series of vertical tubes or sheets, usually within a wrought iron frame, through which air is forced by blowers, driven by steam engines or electric motors, and down through which flows, or sprinkles, or is spread, the water from the condensers. The water coming in contact with the air is cooled and accumulates at the bottom of the tower, and is then pumped into contact with the steam and condenses it. The same water is used over and over, so that only from five to ten per cent. will have to be renewed on account of the evaporation. The five per cent. must be added from the city water works, or other outside sources.

In place of the cooling tower, where real estate is cheap and available, a table can be erected, consisting of a series of boards laid gridiron shape, upon which the water is delivered by the condenser pumps and is sprinkled down through the boards, and the air from the atmosphere penetrating through underneath the shelves comes in contact with the hot water and cools it. It then forms a pool at the base of the shelves and is taken from there and pumped back in contact with the steam in the same manner as in the cooling tower. This device can be installed for the same, or less amount than a cooling tower, and it is advisable to install it where there is sufficient real estate to place it upon, because it requires no power to cool the water, and power is required to drive the fan of a cooling tower.

Motor-driven auxiliaries. Many of the most modern plants are equipped with electrically-driven air pumps, boiler feed pumps, and cooling tower motors, if tower is used. There is a question as to whether this is the most economical thing to do or not. Some believe it to be so. Others maintain that the latent heat derived from the exhaust from the steam cylinders of the steam-driven auxiliaries, if run through a surface or closed heater, more than compensates for the wasteful use of the steam by these steam pumps. I incline toward the belief that there is economy in the use of electrically-driven auxiliaries, on account of the non-wasting

of heat by pipe radiation, if for no other reason, because the primary objects to be attained in a power station are to generate steam with as little fuel as possible, lead it as direct as possible to the steam cylinders, where it is to do its work, and exhaust it into the vacuum as quickly, with as little pipe to radiate heat, as possible, and electrically-driven auxiliaries seem to me to accomplish this result better than any other.

Electric station equipments. The rotary converter is a machine for converting from one form of current to another, or from one pressure to another pressure of the same form of current. A machine for converting alternating to direct current, or *vice versa*, consists of a single armature revolving in one field, carrying two commutators, one direct on one side, and three-phase, two-phase, or single-phase rings on the other, being capable of taking alternating current into the phase or ring side, and delivering direct current on the other, or commutator side.

These devices are coming rapidly into use for transmission work. A number of the most modern railroads in Europe and in this country have been equipped in this way during the past year, and with excellent results. There is one road where this device has been put in under my own supervision, which has been operating very satisfactorily since the first of last July, transmitting three-phase at 5500 volts and then converting it to direct current and delivery out on the line of 600 volts. In most cases 95 to 97 per cent. efficiency may be depended upon, if the machine is reasonably large and operated at full load.

Under this head may be classified the synchronous motor driving series arc machines. One type of modern central station is utilizing its old series arc machines for supplying other circuits by driving them with synchronous motors, in case it is an alternating plant. This makes a very good combination and eliminates belts entirely from the station. The efficiency of such combined synchronous motor with arc machine is seldom more than 72 to 75 per cent.

One device, known as a rectifier, has been used quite extensively in Europe, but not in this country. It consists simply of a commutator revolved by an independent source of power, a small steam engine or motor, belted or directly connected. This commutator will take in alternating current on one side and deliver one, two, or three-phase current on the other, accomplishing the same result as a rotary converter, without the use of the field coils, or any revolving portion except commutators; and it seems to me that we are somewhat behind in not looking into it more thoroughly in this country, for it certainly can be manufactured for less money than the rotary converter. This is mentioned merely as a tendency in transmission work. The efficiency of it is about 97 per cent.

We now come to what is known as the combination generator, which wants a name, and the man who can successfully name it, and have his suggestion generally adopted, will, in a sense, become electrically immortal. It consists of a machine having two commutators and capable of generating current at two voltages. It may be direct current on each end or alternating current on one end and direct on the other; but, in either case, it is a machine deriving its power from an external source in contradistinction to a rotary converter, which revolves itself by means of the current passing through it. These machines are coming into use for railway work, telegraphy, and printing office work. They seem to be the connecting link between the alternating and direct current apparatus. A power station installed with such machines is capable of generating polyphase current and transmitting such current by means of static transformers, to a long distance at a high potential, then running through rotary converters, and delivering out on the line direct current, thus enabling us to utilize our direct current motors which are already installed. The efficiency of such a machine is from 92 to 96 per cent., dependent upon its size.

Boosters are of two kinds, the rotary and the static. The rotary booster is a machine consisting of two dynamo-electric machines, one of which is a motor which may be either alternating or direct current, or arc. This machine is used mainly at the present time for use on long distance feeders in railway and central station work. The generator end of the machine is series wound, and through it passes all the current which goes through the feeder to which it is attached. It is a low voltage machine and increases the voltage on the feeder to which it is attached a sufficient amount to enable current to be delivered at the end of a long feeder at the same pressure that is delivered at the ends of shorter feeders connected with the system. In other words, it is a device to save copper. But when it is used the line loss is increased. However, under conditions where for short periods of the day the load is heavy, it pays to do this instead of adding the requisite amount of copper. It is adopted in a number of the Edison central stations of the country at the present time, and in some railroad plants. It is largely used in stations operating storage batteries, for increasing the potential when charging. The efficiency of such a machine is from 80 to 85 per cent.

A static booster is practically a transformer and is intended to be used upon the long feeders of alternating systems. It performs the same function that the rotary booster does, by raising the pressure of the long feeder to a higher potential, so as to make the current delivered of the proper potential. It has an efficiency of 90 to 97 per cent.

The advantages of the storage battery auxiliary have been so thoroughly discussed of late, that it will be unnecessary for me to enter further into a discussion of its merits. While some engineers are not yet ready to consider its use established practice, its adoption by many of the leading direct current stations of this country should prove its usefulness.

There is one type of machine whose future has not as yet been determined, and perhaps no man can at present safely foretell its future, but there seems to be a demand for it. I refer to the multi-circuit arc dynamo. There is such a machine made to deliver a current for four circuits of about 100 lights each, and if the series arc is to survive, this type, made to deliver current for 5 to 10-100 light circuit, will be the arc machine of the future, and it will revolve at the same rate of speed as our present direct-connected incandescent or alternating machines do, because we must eliminate belts. I am speaking of large stations, and, as I say, if the series arc is to survive, it will be driven by large machines with slow rotative speeds. Such a machine will probably not have an efficiency greater than from 60 to 62 per cent., and that is what militates against it, the same as the low efficiency of the present series arc machine does.

Having thus enumerated somewhat briefly the principal factors which are working to shape the design of the future central station, I will briefly describe two types of stations which have lately been built, and seem to represent the latest practice.

1. The composite station, consisting of two or more independent steam units carrying upon the engine shaft a direct-connected generator suitable for giving light or power, and in addition, a pulley or fly-wheel carrying a belt or rope driving onto a common shaft to which the other engines similarly drive, and from which small direct-current arc machines or other old style machines derive their power. This type is admirably adapted for utilizing out of date machinery. There have been several large plants of this style instal ed in the last two or three years by a leading firm of engineers, and the stations, I understand, are giving excellent satisfaction. I refer particularly to the stations at Toledo and Washington, and the solutions of the particular conditions of these cases seem happy ones, because they enable the owners of the properties to utilize all of their old machinery, until such time as it may be deemed advisable to change.

2. Consists of independent engines carrying direct-connected generators. This type is admirably adapted for plants where but one kind of current is delivered; but in case two kinds are required, it becomes necessary to have a generator of each type upon each engine shaft, or have double the number of reserve units that would be required if but one kind of current were desired from the plant. In either case, the investment in plant be-

comes excessive to insure reliability. Two or more kinds of current can be obtained from such a plant by making all of the generating units alike, so far as kind of current is concerned, and driving secondary generators by means of motors running from the main generators. This means is often adopted in rebuilding old plants for driving the old series arc machines, being directly coupled to an alternating or direct current motor driven from the main 'bus bars. While the stations I mentioned are good engineering, I believe this is better engineering, that is, to eliminate belts entirely; and if we have a number of different types of machine to drive, we had better produce our energy from standard machines of the same character and size, if possible; then drive the older type of high speed machine directly connected from motors, and the efficiency of the combined plant will, I believe, be better than where the belted type is used.

3. There is one other method of construction which I will not class as accepted, but mention it as a tendency in power station design, known as the Arnold system. There have been several of the plants installed, in which the generators are carried on independent bearings, and all made available from more than one engine; but, as I do not wish to take advantage of you, I will refrain from discussing the merits or demerits of this sytem. It is claimed by its advocates to have certain advantages.*

In conclusion, we all know that our ideal central station will be designed when we have secured an electric generator capable of producing energy for universal use, and the necessary auxiliaries in the way of motors and lights to satisfactorily use this energy for all purposes when distance is taken into account. Our expectations and our hopes point toward the alternating machine, but before we can accept it as our ameliorator we must ask its advocates to produce a motor which will start and operate successfully on variable loads without seriously affecting the balance of the plant, and of producing a given amount of light with the same energy and cleanliness that is now provided by means of the direct current arc and incandescent lamp.

I, personally, lean toward the alternating system, but if we are frank with ourselves, we must admit that while the promoters of the alternating system have made very rapid strides in the last five years in the perfection of their machinery, and have overcome difficulties which five years ago seemed insurmountable, there are certain elements yet which they have not overcome, and which we hope they will overcome, and when they do we have come out of the wilderness. But the chief difficulty of the present time is in getting an alternating motor which can be used on such work as printing press work, which is exacting in the extreme; upon electric elevator work, which is one of the chief sources of revenue for central station plants, especially in large cities; and an arc lamp which will run upon practically the same energy as a direct series arc lamp. The alternating arc lamp of today has been greatly perfected, and is almost perfect so far as the quality of light is concerned, and absence of noise. It, however, has a slight deposit of ashes in the globe which requires it to be cleaned oftener than the direct current lamp, and absorbs or consumes somewhat more energy than the other type of arc lamp, and while it is to be hoped that these objections will be removed, and they probably will be, we have not yet reached the point where we can place them exactly on a par with the other type of lamps.

I believe that the connecting link between the present direct current station and the future alternating central station, lies in what I have mentioned before, in the combination generator. We can install machines today which will produce both direct current and alternating current and which will drive our present direct current motors satisfactorily, until the time comes when the alternating motor is perfected. Then, by simply taking off the commutators of the same machines, you can convert them immediately to do alternating work, without any additional expense. I believe that the central stations of the present, and for several years to come, will be designed on these lines and with combination machines.

*The "Arnold system" is a direct connected system throughout, no belts being used. There has recently been a 5000-kilowatt plant installed under this system, 1500 kilowatts of which is now running, and a brief description of this plant will give an idea of the system. One engine is installed with a shaft terminating in a flange. Sufficient room is left for two generators, and then another engine is installed, having a flange on each end of its shaft to which to connect generators. Between the two engines are placed two generators having their shafts in line with the engine shaft. These generators are mounted on hollow shafts or quills carried in their own bearings. Beginning at the end of one engine shaft and extending through the quills, not touching them, to the other engine shaft, is an auxiliary shaft carried in two bearings near its center. With this auxiliary shaft, which is independent of either engine or generator shaft, either one or both the generators between the engines can be connected to either engine when in motion or standing still. This interior shaft does not revolve under normal conditions, but lies idle to be taken up in an emergency, and under normal conditions you drive directly-connected. Machines, generators, and engines may be added in line at any time, and with a new engine four generators will be available from each large or interior engine. By making the end engine extra strong, so that it will carry 100 per cent. overload, which can very easily be done with slight increased cost, in case the large engine lets down, two generators may be run at full capacity from the small engine until the large engine is again ready for work. This requires much less investment in plant than would otherwise be necessary to meet this emergency with independent units of power.—ED.

Transportation

RAILWAY ELECTROLYSIS POPULARIZED.

[COMMUNICATED.]

VAGUE indeed are the ideas prevailing among the greater part of business men respecting the electric current. The action of this invisible agent, so dreadful in the thunderstorm, so grand and beautiful in electric lighting—reaching its culmination in the display of the aurora borealis—so powerful and obedient when used as a motive power, and so awe-inspiring when some unfortunate lineman inadvertently places his hand on one of those small, ordinary looking copper wires and is instantly stretched out a corpse; there is little need for wonder that imperfect ideas should prevail, especially when those who know most about it have much yet to learn. The electric current is now proving so useful that we see some manifestation of it continually and there appears to be no end to the uses to which it is being applied.

In its primary state it is energy in motion the same as wind is air in motion. It may be of so faint a nature as to be outside of the reach of the most sensitive instruments that have been invented. From this vanishing point it has been found to be possible to amplify and energize the current to almost any extent. To illustrate: We take a quantity of water to a suitable pressure machine and we can put energy or power into it to almost an unlimited extent; this water has not changed its form, it is the same weight and has the same familiar appearance, but a few drops would as surely kill as the electric current. We lay small, strong steel pipes through the streets and take small pipes from them, and in the factories attach them to machines of any required size and duty; the water, after the power is extracted by the machines, runs off by the waste pipe harmlessly.

It is not as easy to procure a supply of the electric current as it is to procure a supply of water. The chief source of supply at the present time is the coal pile. As there is a demand for a large amount of the electric current, we obtain it by attaching a machine called a generator to a prime mover and it readily supplies all that is needed. A small steam engine will furnish a small amount of current, and this amount increases with each increase of power.

A current of electricity flows from the generator, when actuated, the same as water flows from a pump when actuated by an engine for that purpose. But the current of electricity is of no value for power purposes unless there is power put into it. This corresponds precisely with elevating a quantity of water, which, in falling back to the earth, can be made to give up that power. To put water under pressure is the same as elevating it. So with electric current when power is put into it and it is sent forth to do work; it is then spoken of as having voltage. Thus we have currents of 1, or 2, or 500 volts pressure: this is the measure of the potential force. Low pressure currents are used in metallurgical works for depositing metals; for electric lighting, pressures of 100 or 200

volts are commonly used, and for driving street car motors a pressure of 500 volts generally prevails.

These currents are sent forth from the generator on a copper wire. To conserve this energy until it reaches the place where it is to be used, and so earn money, it must not be permitted to leave the wire, which, in railway work, is carefully insulated, or electrically isolated from the earth, because, if by any means it could reach the ground the voltage would instantly be absorbed by the earth and the power would vanish the same as if the faucet of the water power pipe or hydraulic main were opened wide. When the power has been entirely used the electric current has been rendered practically inert. The rate of flow of the electric current sent along the wires is measured by amperes, the same as we measure water by the miners inch, and amperes of electric current are as capable of measurement (when passing through an instrument called an ampere meter or ammeter) as time can be measured by a clock. Thus we have a small current of one ampere or more used in metallurgy or telegraphy, or of ten amperes for arc electric lighting, while street cars generally require an average current of fifty amperes. The amperes represent the current itself, and the volts show the strength or electric pressure exerted on the current. It is the amperes that do the work and they represent one factor of the cost of electrical energy; the volts represent the remaining factor.

But there is a very singular thing connected with the supply of the electricity, and this may be illustrated by returning to our hydraulic main. Imagine, if you can, that this great city is located in the desert of Sahara, or in some such place where water is remarkably scarce, in which event the company owning the electric power station would see to it that every drop of water used for power in the various machines, shops, elevators, etc., was returned to the works to be used again *ad infinitum*. The company could not afford to pump the water 10,000 feet from the bowels of the earth whenever it needed water, for it might thus take three times as much power to pump the water as to put power into the water when finally obtained. It is just so with the electric railway companies. The duly energized current is carefully conducted along the railroad line and from time to time the feeder is tapped to the trolley wire; thence it rushes to the motors driving the wheels. The volts put out by the generator are all consumed by the time the amperes have been forced back to the power house, and this consumption of voltage occurs in three ways: (1) in the trolley lines and feeders; (2) in the motors, (3) in the track and earth return, but as the track is generally defective as a conductor of electricity, the amperes are absorbed by the earth in such a manner that before they have become spent they have time to work great mischief amongst water pipes, gas pipes, and the structural iron of great buildings. These effects become more apparent when there is an insufficient path for the spent current to return to the power house. The current possesses an irresistible tendency to return to the power house from any point where it may be liberated from the servitude of driving motors or lights, but it is a fact that very little pains are frequently taken to insure its safe or proper return.

Many tramway people do not see these things in this way and they go on sacrificing their own well being and pumping the cities full of injurious and dangerous currents. The railroad authorities are shown clearly to be sacrificing money in not caring as much for the spent current as for the live current.

It is a well known fact that for the installation of machinery to operate any electric road, steam power must be applied equal to a pull for each horse-power of 30 pounds per ton on a level grade. In locomotive engineering a pull of eight pounds per ton on a level grade is the proper allowance for one horse-power, showing that electric railway engineering is nearly four times more expensive than it ought to be. Moreover, the tracks on which electric cars are operated are superior in every respect to the steam roads.

The rails of electric roads can be made into fine conduits for the safe return of the subtle current, which will never leave a good channel, path, or conductor for a poor one. The earth is a bad conductor of current; iron is a good conductor; copper is better. From the power house the current is carried on large wires, the greater the number of amperes the greater the capacity or area required in the wire; the voltage does not require to be considered, but when the voltage increases, the insulation has to be made more perfect and secure. After attaining a distance of say two miles from the power house, wire of less diameter is used as about one-third of the current has generally been used on reaching this distance. After reaching the fourth mile the area of the feeder is again much reduced, and near the end of the route the trolley wire alone carries the last of the current. Ordinarily, the total area of copper wires leaving the power house on any one route is less than a rod of copper one inch in diameter. For a return path the area should be larger on the same principle that we make the exhaust pipe of the steam engine larger than the feed pipe. Iron is not as good a conductor as copper, the ratio being nearly 7 to 1. The weight of rails used on the electric railroads is generally over 70 pounds per yard; such a rail has an area of seven square inches, which is fully equivalent, as a conductor of electricity, to a square inch of copper. The route has, say, four rails, hence it affords a pathway for current four times as large as that of the live wires from the power house at their greatest cross section. But, as the rails are in lengths of 30 feet and are joined together by bolted fish plates, this break in continuity is fatal to the passage of the current and must be bridged over. This is done by "bonding" or attaching copper wires, joining one rail electrically to another. The copper wire thus joining the rails together should be larger in area than the cross section of the feeders at that point.

Bonding has been found to be a most difficult problem, and on many lines the bonding is almost useless for many reasons. Then came the cast iron and welded joints which were loudly proclaimed to afford a perfect solution of the difficulty; but now, after incurring very great expense for these joints, they are found to be also defective and water pipes have still been greatly damaged in their neighborhood. The melted metal coming in contact with the cold metal acts as a mold, causing a skin to form upon the coating, offering great resistance to the passage of the current which wanders off seeking an easier path. It thus finds a water or gas pipe within a short distance and travels along it, leaving its mark at the lead joints, or elsewhere, and at times causing deposits inside the pipe. The actual damage done to iron pipes and structural iron may be described as a species of rottenness, the familiar metallic features becoming quite changed so that they may be easily cut away with a pocket knife.

The failure of the cast and welded joints to carry current in a satisfactory manner is much to be deplored, because they have given a great amount of solidity to the track and also entirely obviated the movement of the joints in a vertical plane. They have also confirmed what engineers have well known, viz.: that proper construction of the track would entirely obviate the necessity of making provision for expansion and contraction. Electrical engineers (so-called) are behind the age in still providing for expansion and contraction in their bonds when none is required. The present practice of casting and welding joints might easily be perfected so as to remedy the present defect. It simply requires for each joint five cents worth of copper in one or more pieces having together the same area as the feed wire carrying the live current from the power house, to be fixed to the steel rail ends in a workmanlike manner so that the area of the surface of the steel in contact shall be seven times the area of the copper. Then proceed with the casting or welding of the joint so that no copper shall be visible. This will furnish a path for the current superior to any in existence.

According to present appearances the greater part of the street railroad companies are doing practically nothing to remedy the evil which now exists in greater or less degree in every city in the union. The water and gas companies are, therefore, showing signs of increasing uneasiness, and from their standpoint it is not

Continued on page 46.)

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EDITORIAL.

THE LIMITS OF ELECTRIC POWER TRANSMISSION.

It is often profitable to revert to the earlier days of an industry and look over, with a view of comparison with subsequent developments, the reasonings then advanced along what may be termed prophetic lines. Such an article is that of Mr. Alton D. Adams, written in 1895* on "The Limits of Electric Power Transmission," in an opening paragraph of which appears an expression of opinion that, in the light of developments of the present, is eminently sound. "While long distance transmissions may form attractive experiments," states Mr. Adams, "it must be demonstrated that it is possible to thus deliver power more cheaply than it can be generated at the point of use, before they can be common. The cost of transmitted power increases with the distance, and it is obvious that, assuming absolutely free power at the start, a distance may be chosen great enough to consume its entire value in the cost of transmission. To make, then, the transmissions of power commercially practical, it is necessary that the cost of transmission be less than the difference between the value of the power at the starting point and its value at the point of delivery."

Before analyzing that which constitutes the uncertain element of cost of transmissions, it may be stated that long distance power transmissions are common in California, because fuel and climatic conditions are propitious, and they are common in certain other districts where high priced fuel and reliable water powers combine to make favorable conditions, but it can not be said that Pacific Coast transmissions, depending upon uncertain water supplies, as many of them do, have yet demonstrated their ability to deliver power at their markets at a cheaper rate than it can be produced there by steam. That such transmissions maintain competition with steam is undeniable, and that they make serious inroads into the business of the older steam plants is also true, but nevertheless the steam plants keep on paying dividends, while the transmission plants generally find their main solace in statements to the stockholders or prospective bond buyers to the effect that the earnings have gone into extensions, improvements or betterments.

Let it not be adjudged from this that long distance transmission in California is a commercial failure, for such would be far from the fact as there are some such plants that are in superb financial condition and are investments much to be desired. But there are others in operation where the investor has been the victim of the perpetrator, rather than being benefitted by the promoter. The technical success of electric power transmissions is now well established; their commercial success is indeterminate by any other rule than that of a rigorous, thorough and conscientious analysis of all local conditions pertaining to each and every feature of the installation. In brief, every transmission project soliciting financial aid may well be considered as spurious until its promoters shall do the equivalent of issuing a prospectus challenging an investigation of the reliability of its water rights, of the value of the market to be supplied, of the technical feasibility of the points involved, of the total cost of delivery, and, finally, of the cost of production of the steam or other power with which it may come into competition.

A promoter, or a perpetrator, if he be such, who has a transmission project to float, will, figuratively speaking, take the prospective investor to the power house of the steam plant where seething furnaces devour tons of coal each day, and will there point out to him that the firemen are shoveling hard dollars under the boiler, or mayhap, that the quantity of dollars to go under the boilers is so great that it can not be handled by perspiring firemen, so ponderous mechanical devices known as stokers have to be used. The investor nods assent. Then a trip to the mountains is carried out at a propitious season and the prospective investor stands in awe at the thundering grandeur of the mountain stream, roaring down the canyon in torrential flood. "These are Nature's forces," shouts the promoter, "forces like those which cause the earth and tides and the sun and moon to revolve, and by harnessing them we can run every wheel in the country!" Again the prospective investor nods assent, and within the day he has become an enthusiastic convert.

Then follows the period of construction, the money is ready and all progresses smoothly; the inauguration of the enterprise is blared to all quarters as the opening of a new era and congratulations and champagne mingle merrily.

Chapter three opens with a list of "unforseen" emergencies that is appalling in its length: counter movements of rival companies, extension expenses for distribution purposes, plant enlargement for different character of service than originally contemplated, alterations in the engineering designs of the original plans, washouts and breaks in flumes and ditches, drouth and partial or total failure of water supply, auxiliary steam plants and additional generators, transformers and station equipment for the same, current bought from outside sources for emergen-

*The Engineering Magazine, Vol. X, No. 2, page 269.

cies, and, finally, the securing of a big contract containing a provision that steam must be kept up at all hours on an auxiliary plant in order that continuity of service may be better assured. Then as to cases in which water rights have not been fully acquired: an instance wherein a water company charged six dollars per horse-power per month for the right to use water flowing past a power house—$1800 in gold per month for 300 horse-power in water simply diverted and returned to the ditch again—is not without precedent. It is in such preventable exigencies as these that the commercial limitations to electric power transmissions are largely to be found.

Chapter four is yet to be written, but the sequel to the story may easily be foreseen. While electric power transmissions have given the lie to the revered adage, "the mill will never run with the water that has passed," still they cannot conjure with magic and they must face the inevitable fact that there is, after all, no difference in whether money is consumed in coal burned under steam boilers, or whether it is consumed in interest and fixed charges, so long as the amount in each case remains the same. And in this very point of the amount of money consumed in each case rests the solution to the problem of the limitations of electric power transmission, but to find the solution, analyses must be made of local or specific conditions—not prevailing generalities.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

THE FUTURE OF NON-LUMINOUS GAS.

Dr. H. Bunte, in his "Observations upon Water Gas,"* points out that since by the Welsbach incandescent gas light, non-luminous coal gas has become a peculiar light dispenser, and since the same result can be attained with non-illuminating water gas, the economic adoption of the water gas process betokens an advance which the illuminating gas industry has every cause to keep before its eyes. "Not a hostile competitor," continues Dr. Bunte, "but as a confederate, we take the liberty of addressing this rival who makes it possible for the gas industry, even though father in the future, to hold in its right hand light, heat, and power. And indeed, we ask ourselves the question, Will our coal gas now, as ten years ago, exclusively, or even in great part, be employed as illuminating gas? Have the illuminating constituents of coal gas, which we measure with the photometer, still the same value as ten years ago before the Welsbach burner made its entry into the domain of gas illumination? We must answer this question in the negative. Everywhere where the Bunsen burner has appeared, whether it be as a gas light or for cooking and heating, the illuminating constituents are purposely destroyed before use converts them into a non-luminous heating flame. The more extensive incandescent gas lighting becomes, and the more extensive becomes the employment of gas in heating and cooking, the more do the illuminating constituents of coal gas diminish in value."

When Dr. Bunte asks whether the illuminating constituents of coal gas still have the same value as prior to the entry of the Welsbach into the domain of gas illumination, he might with equal propriety have included the illumination constituents of water gas. The development of the Welsbach seems, from this line of reasoning, to be destined to make nugatory the present all but universal practice of enriching water gas by the introduction of the hydrocarbons derived from oil. What then, it may be asked, stands in the way of the eventual use of non-luminous gas (which is but another name for fuel gas) for the universal use of gaseous light, heat and power? This at least is the opinion of Mr. James Stelfox in his inaugural address as president of the Incorporated Gas Institute at Belfast, in June, 1898.

This address, by the way, gives serious consideration to the claim that it was found at the Vienna General Hospital that, for a given amount of light in Welsbach mantles, uncarbureted water gas, made on the Strache method, developed only about one-third of the amount of heat produced by a similar burner consuming coal gas, and the production of carbonic acid was only one-half; while comparing it with the products of coal gas consumed in ordinary burners, the heat produced was only one-eleventh, and the production of carbonic acid less than one-seventh.

BREAKING DOWN THE BARRIERS OF CONSERVATISM.

The over-conservatism with which the mining interests have long looked upon the introduction of new appliances, and particularly electrical equipments, into their business methods has perhaps done more to retard the use of electrical devices in that direction than has any other single element; but in the long run merit will tell and in every industry there are always minds which are free from prejudice and which stand ready to adopt whatever there is of the new that improves upon the old. Through the spirit of progression which pervades this class of the mining industry, electricity owes the high attainment it has reached in the various channels of mining development. The field has long been an inviting, though not a yielding one, and it can but be gratifying to note the favor with which electrical appliances are now being held in practically every branch of mining work.

Witness, for instance, an editorial statement in the current number of *The Engineering and Mining Journal*, which says that for many years it has been acknowledged that electricity can furnish the power for every line of mining work. At first it began with signaling, then blasting, and there was a pause. The idea of using electricity as a power for heavy work seemed absurd when exemplified to the ordinary observer in a current carried by a little copper wire. It was in Colorado that the first application on a large working scale was applied, and the combination of water power and electricity was put in practice. The installation at the Virginius mine is a familiar example. "Now we find," continues our contemporary, "electricity employed for hoisting, pumping,

*The Gas World, January 14, 1899, page 54.

drilling, and all the operations of mining. There was a hitch about the drill, the gadder, and the coal cutter, but it seems to have been overcome; so that it is now safe to say that there is nothing done in mining which can be done by steam power directly, or indirectly by compressed air, or wire rope transmission, which can not be done equally well by electricity—the selection depending upon difference in first cost, running expense and maintenance. The strange thing is that in some cases electricity has helped its competitors, as, for example, in the combination with air compressors."

THE MOUNT WHITNEY TRANSMISSION.

Through the application of electric power the problem of irrigation in California has been greatly simplified. Up to the present time pumping stations have required steam or gasoline engine plants which often necessitated the transportation of fuel over considerable distances, making the operation quite costly. The utilization of the electric motor for operating pumps in supplying water from artesian wells will eliminate the use of these plants wherever electric service can be more cheaply rendered.

One of the largest and most important electric power plants of this description has recently been contracted for by the Mount Whitney Power Company, of Visalia, Cal., with the Westinghouse Electric and Manufacturing Company. The project as it is to be carried out is an extensive one, involving three 600 horse-power alternating current generators direct-connected to water wheels, two direct current generators for exciting the fields of these alternators, and four 500 horse-power raising transformers, together with all other necessary auxiliary apparatus.

From the central station, where the above machinery will be installed, the current is to be transmitted to five sub-stations conveniently located with respect to the artesian wells. In these sub-stations are to be placed step-down transformers and switchboards for receiving the current from the transmission circuits and delivering it at a lower potential suitable for operating the various motors located at each of the sub-stations. The motors are to be connected to the pumps for drawing water from the artesian wells, thus keeping up the irrigation of the land as may be required. The contract calls for eighteen Westinghouse motors ranging in size from ½ horse-power to 30 horse-power, and the sub-stations are located at Lemoncobe, Lindsay, Porterville, Tulare and Visalia. The Mount Whitney Power Company proposes also to distribute a portion of the current from the central station to the city of Visalia for light and power purposes. Work on the entire system is now being actively prosecuted.

CASSIER'S ELECTRIC RAILWAY NUMBER.

There have probably never been published two more remarkable numbers of any periodical than the marine number and the Niagara power number of *Cassier's Magazine*, which appeared in 1897 and 1895 respectively, each containing several hundred pages of text and illustrations, with all articles prepared by men of the highest standing in their several professions and with illustrations of the first order of artistic merit.

The highly gratifying success attending the publication of these two remarkable specimens of engineering literature has prompted the Cassier Magazine Company to commence the preparation of another special number, to be devoted to electric transportation, and will be known as the electric railway number. As in the other two cases, the contributors which have been secured for this number are men of the highest professional standing, and what they have written is of enduring merit. There will be about fifteen articles relating to all branches of electric railway construction, maintenance and operation, and all together will constitute a volume which should be in every electrical and mechanical engineer's library.

RAILWAY ELECTROLYSIS POPULARIZED.

(*Continued from page 43.*)

difficult to foretell that, unless correctives are applied, the time is surely coming when many of the street car systems now enjoyed will be tied up by injunctions. This would be to the embarrassment of thousands who have built homes in the suburbs, as well as the ruin of those who have placed their funds in the securities of those companies.

In Dayton, Ohio, the city has a just claim against the Peoples' Railroad Company for $100,000 for destruction of water and gas pipes on a partial investigation; and the mischief still goes on. The railroad companies of Brooklyn, N. Y., are now being sued in the courts for damages laid at $3,000,000, and two hundred suits are likely to be added, with additional claims of $17,000,000.

Municipal boards are composed of business men chosen because of their business qualifications. Very few have had time or inclination to study the subject under consideration, but there is a way of looking at and dealing with the matter which may perhaps commend itself to such boards and which requires no technical knowlege to understand. The proposition is to enact an ordinance which shall require every electric railroad company doing business within the city to furnish daily a statement under the official seal of the company of the amperes of current sent out over each and every route owned by the company, the readings to be taken from recording ammeters placed in the outgoing feeders at the switchboard of the power house and read each hour of the day or night during which the engines may be operated. The railroad company shall also cause wires to be attached to each rail of said route or routes when it shall reach its nearest or most suitable point near the power house, as well as to ground plates and each water or gas main adjacent, and cause said wires to be connected to similar recording ammeters in such manner as to measure hourly the number of amperes of electric current returning to said power house. Thus will be obtained a record at each hour of the day of the outgoing and returning currents, these records to be duly placed on file. If, from a consideration of the record, it should appear that there is no current returned by the rails or any rail, or ground plates, or if the conductivity of any rail or ground plates did not reach a specified percentage, then the railroad company should be directed to provide a remedy within a certain specified time, subject to such extension as may be considered proper.

Electric lighting companies should also be required to furnish daily statements regarding the outgoing and returning currents, and instruments used in measuring the currents and also the wire connecting the rails with the instruments, should be open for inspection at any time by any duly authorized city official.

MR. W. F. C. HASSON, of the late engineering firm of Hasson & Hunt, states that he is winding up its and his own business affairs preparatory to moving to the Hawaiian Islands, where he proposes to locate.

Gas

ACETYLENE.*

BY PROF. VIVIAN B. LEWES, F. I. C., F. C. S.

IV.

A CONSIDERABLE amount of vagueness exists as to what is meant by the illuminating value of a gas, and the only assumption which can be arrived at is that it is the highest illuminating effect which can be produced from the gas without the aid of regeneration or artificial air supply other than that created by the flame itself. The proper combustion of any hydrocarbon gas, however rich, can be effected by supplying the flame with exactly the amount of air necessary to prevent smoking, and it is under these conditions that the highest illuminating effect possible with the particular burner is obtained. With flat flames the ratio between the air supplied and the gas consumed is governed by two factors: (1) the thickness of the flame; (2) the pressure under which the gas issues from the burner. When a gas issues from a burner under pressure, the uprush of the escaping gas mechanically draws in air, so that when consuming a poor coal gas in a flat flame the pressure has to be kept down, or too much air would be dragged in which would consume the hydrocarbons too rapidly, and so seriously effect the amount of light emitted, whilst, as the gas increases in illuminating value, more and more air is required for proper combustion, and this can be obtained by increasing the pressure at the burner.

Experience has shown that with ordinary sized, flat flame burners seven-tenths of an inch in pressure gives practically the best results with coal gas of the quality supplied in London, and up to a certain limit the same flat flame burner can be used for richer gases by increasing the pressure. When this limit is reached a thinner sheet of flame has to be employed; *i. e.*, a smaller burner used, low initial pressure resorted to, and then, by increasing pressure this can be made to consume gases of increasing value, until the pressure reaches a point at which the flame becomes distorted, when a still smaller burner has to be taken. By such means as these even acetylene, with its enormously high illuminating value, can be satisfactorily consumed, whilst by thickening the flame and reducing the pressure to the point at which the uprush almost ceases to cause a mingling of air with the flame and leaves the supplying of the oxygen to diffusion, even a poor gas can be made to develop its illuminating power.

BURNERS.

On consuming acetylene from a No. 000 union jet burner, at all ordinary pressures a smoky flame is obtained, but on increasing the pressure to four inches, a magnificent flame results, free from smoke, and developing an illuminating value of 240 candles per five cubic feet of gas consumed. Slightly higher values have been obtained, but 240 may be taken as the average value under these conditions. This figure is the one quoted by most manufacturers of acetylene apparatus, who argue from it that acetylene is 15 times as valuable in illuminating power, volume for volume, as London coal gas. Such a comparison is, however, absolutely misleading, as in contrasting the value of acetylene with coal gas, one must bear in mind that the illuminating power of London gas is determined by consuming it at the rate of five cubic feet per hour in the London argand, whilst in practice any power from 8 to 90 candles can be obtained from this volume, according to the form of burner in which it is consumed. Although small flat flame burners only emit from one to two candles per cubic foot of gas consumed, good incandescent mantles will yield about 18 candles per cubic foot, and certainly 17 on the average, and as incandescent gas lighting is rapidly displacing other methods of burning gas, and as this tendency will be enormously increased when the lapsing of the Welsbach monopoly reduces the price of the mantles to the figure now charged in Germany, it is evident that no calculation is fair that does not include this as a factor.

Moreover, a very short experience soon shows that burners consuming one cubic foot of acetylene per hour are the largest that can be practically used for domestic purposes, and taking such burners all round, 32 candles per cubic foot is a fair average of the light developed by them, although out of a big batch of burners you occasionally find a few which will go as high as 36 or even 40 candles per cubic foot. As the consumption of acetylene is regulated by exactly the same factors as act in the case of coal gas, it is evident that the smaller the burner and consumption, the lower will be the candle power per cubic foot of the acetylene. In practice, with a one-half cubic foot burner, 24 candles per cubic foot is a good result.

The only fair way to contrast the light obtainable from coal gas and acetylene is to take the incandescent burner on the one hand and the one cubic foot flat flame on the other. Then it is seen that instead of having 15 times the value of the coal gas as an illuminant, it has only about twice its power. The acetylene burner, however, has one advantage over the mantle, and that is that you can more or less regulate the light to the amount you require.

When acetylene is burned in air, under such conditions as to complete its combustion, it is converted into carbon dioxide and water vapor, the same compounds as are produced by all combustible hydro-carbons:

HEATING AND VITIATING EFFECTS.

$$2C_2H_2+5O_2=4CO_2+2H_2O.$$

One cubic foot of acetylene requires 2½ cubic feet of oxygen. The researches of Dr. Gréhant have shown that when burning with a smokeless flame no carbon monoxide can be detected in the products emitted by its combustion, and its sanitary position will, therefore, be defined by the amount of oxygen abstracted from the air and of carbon dioxide produced, as compared with other illuminants.

Taking the average sized room, which would be well lighted by an illumination equal to 64 standard candles, we find that this amount of light, from various illuminants, would yield the following results:

Illuminant.	Oxygen Removed from Air. Cubic Feet.	Products of Water Vapor. Cubic Feet.	Combustion Carbon Dioxide. Cubic Feet.
Sperm Candles	38.5	26.2	43.6
Paraffine Oil	24.9	14.0	39.8
London Gas—Batswing	26.1	29.4	19.2
Argand	23.0	25.6	17.0
Regenerative.	10.6	8.3	5.2
Incandescent.	3.1	4.6	1.8
Acetylene	5.0	2.0	4.0

So that, light for light, acetylene fouls the air less than any of the ordinary illuminants, with the exception of the incandescent gas burner.

In comparing the heating effect of various illuminants on the air of a room, it is necessary to determine the calorific value of the combustion of a cubic foot of the illuminating gas employed, and it is manifest, from theoretical considerations, that a highly endothermic compound like acetylene must have a far higher heating power than ordinary coal gas. The mean of a number of experiments made in Junker's calorimeter gave as the thermal value of the ordinary London gas supply 158 calories, whilst under the same conditions acetylene yielded 320. The theoretical amount of heat emitted by the combustion of a cubic foot of acetylene is 349.08 calories, but this would only be given by the absolutely pure and dried gas, and the experimental number determined in the calorimeter represents more truly the heating power of the moist gas under ordinarily existing conditions.

Taking now the case in which a room is lit up with a power equal to 64 candles, we find that if we call the heating effect produced by an incandescent mantle giving this amount of illumination 100, then:

Ratio of heat emitted to yield a light of 64 candles:

Incandescent mantle	100
Acetylene	115
London Argands	571
Flat flame burners	914

*Abstract of the last of a series of four Cantor lectures delivered to the Society of Arts, London.

So that, for all practical purposes, the heating effect on the air by acetylene illumination is the same as with mantles.

ACETYLENE VERSUS COAL GAS.

When one comes to compare the cost of acetylene and coal gas, one is again struck with admiration at the statements made by the advocates of acetylene as a rival to the well established coal gas industry. At the present time the wholesale price of carbide is £20 a ton, but I believe that, to fill large cash orders, it can be obtained at £16, at Foyers, which would mean at least £20 a ton at the works where it is to be decomposed and the gas distributed. The decomposition of carbide is not only a costly operation, but at least 10 per cent. would have to be added to the price of the carbide for handling, water, repairs, interest on plant, purification, etc., and this would bring the price of the acetylene to £2 per 1000 cubic feet in the holder. Coal gas in the holder, when made on the scale common in our big cities, costs about 1s. 2d. per 1000 cubic feet, and about 100 per cent. has to be added to this to cover charges of distribution and profit. The power of doing this is dependent on the amount of gas sold, and whilst the South Metropolitan can make a fair profit on gas at 2s. 3d. a thousand, there are many small country works that can not pay a dividend with gas at three times the price. With acetylene the smallness of the output would necessitate a heavy charge over cost price, and I should be surprised to find an installation of acetylene, even in a fair sized town, paying its way with a less charge than £3 per 1000 cubic feet. Looked at from this point of view, it is at once manifest how absurd it is to talk of acetylene as a possible rival of coal gas, and the sooner this is realized the better will it be for the future of this brilliant illuminant.

Abroad, where coal gas is dear, it is possible, by taking the price of acetylene in the holder and comparing it with distributed coal gas to make acetylene out to be, light for light, as cheap as the latter when consumed in a flat flame burner, but even this method of calculation breaks down before the high light emissivity of the incandescent mantle. It is in those districts where no coal gas exists that the true field for acetylene is to be found, and here its ease of generation and the beauty of its light make it a pleasant companion after the greasy dimness of the candle or the smell of the oil lamp.

SMOKING.

The cause of smoking is to be found quite as much in the generator as in the nipple, and over-heating during generation is undoubtedly a prime factor in this worrying phenomenon. If smoke or tar vapor be examined under a high microscopic power, it is seen that it consists of minute vesicles or bubbles, in a most marvelously active condition of movement, and fulfilling in a most perfect manner the conception one forms of molecular motion. Ever bombarding each other, but never colliding, these small vesicles, filled with gaseous matter, continue their career, until some mechanical action bursts them and deposits the minute trace of liquid which formed the skin of the microscopic balloon. It is for this reason that the most successful forms of washer for extracting tar during the manufacture of gas consist of fine jets, or orifices, through which the gas passes at considerable velocity and comes in contact with a baffle which breaks up the vesicles, and any one with experience in carbureted water gas making knows the trouble that arises from filiform growths of carbon, when, owing to an insufficient temperature in the cracking and superheating chambers, the carbureted gas contains vapors instead of permanent gaseous products.

When acetylene has been made in a generator at an undue temperature, it carries with it benzine vapor, which, as it commences to condense, assumes this vesicular form, and on coming to the extremely minute holes which form the apertures of the burner, the mechanical scrubbing which it encounters causes the breaking up of the vesicles, and the decomposition of the benzine and the other hydrocarbons held in suspension by benzine which soak into the steatite and carbonize. The presence of finely divided carbon has a great effect in determining the decomposition of the acetylene itself, so that a rapid growth of carbon takes place at the burner, and no ordinary clearing of the deposited carbon from the exterior will ever make the nipple fit for constant use again, as the catalytic action of the carbon deposited in the pores of the steatite, which cannot be got rid of, causes the deposition of a fresh supply of carbon; whilst when the benzine vapor gets past the nipple and burns, as it requires three times as much air as acetylene, it often starts smoking of the flame from this cause. The impurities in acetylene, other than vapors, also play a certain part in the choking of the burner, as if there be much phosphureted hydrogen in the gas, a small quantity of phosphoric acid is apt to be deposited in the burner nipple and helps to distort the aperture, and silica from siliciureted hydrogen has the same effect.

It will be found, with experience, that the smoking in a burner will be overcome quite as much by attention to the temperature in the generator as to the burner itself; and where a generator which gives over-heating is in use, a well arranged scrubbing apparatus that would get rid of the benzine from the gas would be found a distinct advantage in stopping burner troubles, whilst when proper purification is introduced the burner trouble will be found to have been practically solved.

WELSBACHS.

The incandescent mantle has made such a revolution in coal gas lighting that it is not surprising that attempts should have been made to adapt acetylene for this purpose. The first thing which had to be done, when taking steps in this direction, was to construct an atmospheric burner which would satisfactorily consume the gas. One would expect that acetylene, when consumed in an atmospheric burner, would give an excessively hot flame, not only on account of its composition, but also on account of its endothermic character. Le Chatelier calculates that the temperature of a non-luminous acetylene flame will range from 2100° to 2420° C.; the temperature, of course, varying with the ratio of acetylene to air. In order to make a Bunsen burner for acetylene, the tube has to be extremely narrow, and it is even then found to be very liable to flash back, whilst it needs a high pressure in order to bring about satisfactory combustion of the gas with an absolutely non-luminous flame. One of the chief difficulties which has to be overcome is due to the range over which mixtures of air and acetylene are explosive. This, as we have seen, lies between the limits of three per cent. and 82 per cent. of acetylene; and it must also be remembered that the velocity of the explosion of a mixture of acetylene and air is greater than that of a mixture of air and coal gas. The propagation of the explosive wave down the burner tube cannot be satisfactorily stopped by the ordinary device of using wire gauze, on account of the low igniting point of acetylene and air mixtures; whilst if high pressures are used, so that the rate of flow shall be greater than the velocity of propagation downwards, more air is sucked in by the uprush of the gas, and the velocity of the explosion is again increased. The best results have been obtained by taking a Bunsen burner in which a constriction in the air tube creates a high velocity at that point, which, on the principle of the Smithells flame separator, prevents the propagation downwards just at that point.

Le Chatelier has shown that the rate of propagation of an explosive mixture of air and acetylene depends upon the diameter of the tube through which the wave is being propagated, and has shown that in a tube of 0.02 inch, or 0.05 mm., in diameter, you have the propagation of the explosive wave ceasing.

These investigations have been used as a basis upon which to construct acetylene burners for heating purposes, and burners have been made by the Allgemeine Carbid und Acetylengas Company, of Berlin, in which, by means of const.icted tubes, satisfactory consumption is insured. It is found that the diameter of the tube at the constriction must be in a definite proportion to the particular mixture of air and acetylene consumed, as the more air employed the greater must be the constriction in the strangulated portion of the tube. Such burners have a flame which is very valuable for heating purposes, and which gives a very intense

temperature. The same company has also used these burners with incandescent mantles, of somewhat different shape and composition to those ordinarily employed, and states that the photometric result is 30 to 40 per cent. higher than that obtained by the combustion of pure acetylene alone. I have lately been experimenting with an acetylene Bunsen, and get much higher results than these; as with a Welsbach No. 2 mantle I have obtained as much as 90 candles per cubic foot of acetylene consumed. As far as I have gone, the mantle appears to be hardened and strengthened by the intense heat to which it is subjected; but it yet remains to be seen how the life of the mantle is affected by the intense temperature of the flame. Acetylene atmospheric burners are now also employed for heating, cooking and metallurgical operations on a small scale, and with a reduction in the price of the gas, these uses for it will undoubtedly open up a wide field of utility.

PHOTOGRAPHY AND PHOTOMETRY.

The value of acetylene in photographic work is now universally recognized, and Mr. W. H. Walmsey has determined its relative value, as compared with the ordinary sources of light, by determining the time needed to fully expose carefully prepared plates, with the following results: Direct sunlight, one second; acetylene, one cubic foot burner, three seconds; diffused daylight reflected from mirror, 12 seconds; incandescent mantle, 24 seconds; coal gas, oil gas, oil lamp, 240 seconds.

It is also being used to a certain extent for projection work; but it is not so well suited for this, as in common with multiple wick oil lamps and incandescent mantles the flame offers too large a surface of illumination. M. Molteni has attempted to determine the projection value of various illuminants by a photometric process, in the following way: The measurements were made with an ordinary lantern, the stage of which carried an opaque card in which was cut an aperture 0.7 cubic meter square, and the distance of the lantern from the screen was such that each side of the square on the screen measured one meter. The screen was replaced by a disk of paper, the opposite side being illuminated by a standard lamp burning 42 grammes of oil per hour. The distance of this lamp was varied, in order that equality of illumination might be obtained on the screen, and the photometric values of the lights were determined from the distance of this lamp.

Multiple wick lamp	1
Incandescent gas, No. 2 burner (no reflector)	1
Acetylene, 1 burner (no reflector)	1.06
" 2 " "	1.70
" 3 " "	3.20
" 4 " "	4.10
" 5 " "	4.50
Limelight, alcohol and oxygen	5.80
" oxhydrogen	16.60
" etho-oxygen	18.50
Electric incandescent, 32 candle-power	0.68
" " 50 " vertical	0.93
" " 50 " E horizontal	0.93
" " focus 100 "	3.82
" " E arc lamp 7 amperes	39.03
" " " 10 "	75.61
" " " 12 "	86.50
" " " 15 "	117.61
" " " 20 "	160.80

TRANSMISSION OF POWER.

Carbide will probably some day become an important factor in the transmission of power, as a cubic foot of solid carbide weighs 62.26 kilos., or 137 pounds, and if of commercial purity would yield 685 cubic feet of acetylene, having a thermal value of nearly 232,215 calories. In practice, however, the weight of carbide which can be got into a cubic foot space is dependent on the size to which the material is broken; and with the ordinary commercial carbide, a fair average would be 80 pounds per cubic foot, yielding 400 cubic feet of acetylene gas, with a thermal value of 139,600 calories. It is at once manifest that solid carbide is as economical a method of transporting acetylene as if liquid acetylene itself were employed, as the liquid would only yield about 400 times its own volume of gas; and the carbide has the advantage of being practically safe in transit. There are several people at present working on the utilization of acetylene for gas motors; but there are many difficulties to be overcome before this is successfully accomplished, as the deposition of carbon, when the air supply is insufficient, and the violence of the explosion, are troublesome factors to be dealt with.

The trouble of completely consuming acetylene without smoking, in the early days of its inception, caused Dickerson and Suckert to attempt the combustion of acetylene diluted with air, and in 1894 it was in this way that the gas was consumed. But not only did the cooling action of the nitrogen lead to a considerable decrease in the illuminating power of the acetylene so diluted, but, as will have been seen from the experiments of Gerdes and others, a very serious risk was incurred, it becoming merely a question of the breadth of the delivery tubes and the rate of flow of the gas whether an explosive wave was propagated back to the mixing machine or not. It was on account of the danger of this that this process of burning it was abandoned in America. The idea has, however, cropped up from time to time since, and it has been used in both France and Holland to a certain extent, on a practical scale; and even at the present time an attempt is being made in Manchester to introduce a process by which acetylene can be so diluted with air as to burn in an ordinary Bray burner.

It was about 1895 that Mr. Gerdes commenced his experiments upon the enrichment of oil gas with acetylene, which have borne such ample fruit on the Continent. He showed that when oil gas is enriched with 25 per cent. of acetylene, a valuable increase in its illuminating power is obtained, without any danger of explosion of the mixture owing to heat or shock. This mixture is now employed to a very large extent on the Prussian railways. The quantity of carbide already used this year for this purpose has reached a total of 3000 tons, and it is computed that before the end of next year 10,000 tons per annum will be needed.

ENRICHING.

In consequence of the great Continental success of this admixture, application was lodged at the Home Office to sanction such a mixture in England, under the ordinary railway cylinder pressure of 10 atmospheres. The safety of the mixture, and of mixtures considerably richer in acetylene, was completely established by a series of tests carried out in the presence of the Home Office officials; and, in consequence, by an order of the Secretary of State, dated March 28, 1898, a mixture of oil gas with 20 per cent. of acetylene is allowed to be used at a pressure not exceeding 150 pounds on the square inch.

In order to determine the increase in illuminating power given by various percentages of acetylene in oil gas, and whether the mixture could be employed with economy, the following experiments were instituted: Oil gas containing 20 per cent. of acetylene was compressed into a cylinder under a pressure of 10 atmospheres; some of the original oil gas being also compressed in a second cylinder to the same pressure. Both cylinders were then blown off to 5.8 atmospheres, and the illuminating power of each was taken under identical conditions. The burner used was a "40 liter" one, and the results were as follows:

		Illuminating Value.	
Pressure.	Gas Consumption.	Oil Gas.	Oil Gas and Acetylene.
5.8 atmos.	1 cubic foot.	7.4 candles.	15.6 candles.

An analysis of the gas showed that the mixture contained 22 per cent. of acetylene, although but 20 per cent. was originally added, the increase being due to the loss of some of the oil gas, some of the vapors of benzine and toluene in it condensing to the liquid state under the pressure. Working from these figures it will be seen that the addition of 22 per cent. of acetylene caused an increase of illuminating power of 110 per cent., or 100 per cent. with 20 per cent. of acetylene.

With regard to cost, as we have before seen, acetylene, at the

present price of carbide, will cost about £1 18s. to £2 per 1000 cubic feet in the holder; and 200 cubic feet will accordingly cost 7s. 8d. The compressed oil gas costs from 6s. to 12s. per 1000. With oil gas at 8s. a 1000, 800 cubic feet will cost 6s. 5d., so that the total cost of 1000 cubic feet of the enriched gas will be 14s. 1d. But as the illuminating value of the mixture is double that of the plain oil gas, there is an economy of 1s. 11d. per 1000. As the oil gas is dearer, the saving will be greater; and, *vice versa*, with cheap oil gas the addition of acetylene would not pay. With oil gas at 6s. 6d. per 1000, there is practically no difference, but the advantages accruing from the use of acetylene would make the mixture more desirable than the plain gas. Amongst these advantages are that the cylinders would last for double the length of time they would with the oil gas, with the one charge, and there would be no formation of liquid hydrocarbons due to compression, with consequent revaporizing when the pressure is reduced, causing inequality in the illuminating power.

The whole question of diluting acetylene with other gases has had a very great interest for me, and I have made many experiments in order to determine how it is that when 10 per cent. of acetylene is added to a diluent such as blue water gas, carbon monoxide, or even hydrogen, the resulting mixture is practically non-luminous; and I have worked out the enrichment value for acetylene for all those gases which might be employed for its dilution. I soon discovered from these experiments that methane is the only diluent which sustains the illuminating power of the acetylene when mixed with it in small proportions; and the fact that the same phenomenon is observable in comparing the illuminating power of mixtures of gases containing only some 30 per cent. of methane gives at once a clue to the methods which must be adopted in making a diluting gas for acetylene.

CONCLUSION.

It is perfectly obvious that in many places it would be a great advantage to have an illuminating gas of about 20 candle-power for general distribution, in the same way as a good coal gas could be used, if such a mixture could be produced at a price comparing favorably with coal gas under the same conditions. Although it would be impossible to use pure methane as the diluent for acetylene, on account of the cost of its production, it is quite easy to make a diluting gas which shall contain 30 per cent. of methane at a comparatively low rate. In order to make this a slightly modified form of water gas generator is employed. The fuel having been blown up to incandescence by an air blast, tar, creosote oil, heavy oil residues, or practically any waste liquid hydrocarbon, is injected into the body of the incandescent fuel by a steam injector or atomizer. If these hydrocarbons were allowed to run into the fuel by themselves, they would simply be burned up to carbon and hydrogen; but steam being injected with them, the steam is decomposed by the fuel, with the formation of water gas, which, to a certain extent, envelops the hydrocarbon, and instead of its undergoing complete decomposition, it is broken down to methane and hydrogen, and mingles with the water gas, whilst any residual carbon is left behind in the fuel. It is quite possible by such means to make a diluting gas containing: hydrogen, 45; carbon monoxide, 15; methane, 30; unsaturated hydrocarbons, 5; carbon dioxide and nitrogen, 5.

This gas costs from 8d. to 10d. per 1000 cubic feet, and has an initial illuminating value of about 10 or 12 candles. On mixing it with five per cent. of acetylene, a gas having an illuminating value of 18 to 20 candles is obtained, which, being a mixture of perfect gases, gives no trouble as regards layering, and which, having the same specific gravity and illuminating value as coal gas, can be distributed and burned in precisely the same way. It is also found that mixtures of this gas with 50 per cent. of acetylene are not detonated, when compressed for railway carriage lighting, by any temperature which it would be possible to attain in the cylinder, and it seems that this method of utilizing acetylene is pre-eminently the one which promises for it the largest and most remunerative future.

I leave my subject with the sincere hope that as time wears on, those points which appear to us now to be difficulties will be made clear, and that in the future cheapened carbide will enable this beautiful hydrocarbon to take its proper place in the foremost ranks of our illuminants.

SOURCE OF LUMINOSITY IN THE WELSBACH MANTLE.*

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WELSBACH mantles have effected a great revolution in artificial lighting and have made gas absolutely unapproachable at present by its competitors as a cheap illuminant. The mantle consists, as is well known, of a delicate network of the rare earth, thoria, with a one or two per cent. admixure of ceria. This is placed over a non-luminous Bunsen flame, the heat of which renders the mantel powerfully incandescent. The function of the gas is to generate heat, and that of the mantle is to transform the non-luminous heat energy into luminous light radiation.

It is curious that neither a mantle of pure thoria nor one of pure ceria is at all efficient for light emission, and the wonderful incandescence which results from adding less than two per cent. of ceria to a thoria mantle is difficult of explanation. It is frequently ascribed to catalytic action causing great local intensity of combustion somewhat similar to that which induces the union of oxygen and hydrogen in the pores of spongy platinum. Doubt seems to be thrown on this theory, however, by the fact, established by Le Chatelier, that the light emitted by the mantle is the same whether it is heated in the hot gases at the required temperature before or after they are burned.

Another explanation which commends itself to the writer is based upon the fact that the emitted waves of a pure thoria mantle are largely ultra blue, or too fast for vision, and those from a ceria mantel are ultra red or too slow. It is suggested that the admixture of ceria so loads the thoria particles as to tone down their vibrations into the bright range of the visible spectrum, and thus to make evident to the eye rays which would otherwise be invisible. But to whatever cause it may be due, the emissive power of the Welsbach mantle is certainly remarkable.

CHEAPER GAS FOR POWER PURPOSES IN BOSTON.

CHEAPER gas may be expected to induce a general increase in the use of gas engines, and a movement is now on foot in Boston which may exert a marked influence in this direction. The *Engineering Record* states that Mr. H. M. Whitney, president of the Brooklyn Gas Company, and who controls large coal resources in Nova Scotia, has asked the city authorities of Boston for the privilege of supplying coal gas of 18 candle-power containing less than 10 per cent. of carbonic oxide, at the rate of 75 cents per 1000 cubic feet when used in gas engines for power purposes. The price is to be 1½ cents in engines up to 100 horse-power, 1$\frac{1}{10}$ cents in engines from 100 to 200 horse-power, and in engines of more than 200 horse-power the cost will be one cent per horse-power hour.

Mr. Whitney further states that the cost of electric power in Boston is from 3½ to 7½ cents per horse-power hour, depending upon the quantity used. The cost of fuel for a steam engine on a basis of six pounds of coal per horse-power is the equivalent of 1½ cents per horse-power hour, but this economy can not be obtained in small engines that are in common use. The average consumption of small engines is estimated at about ten pounds of coal per horse-power hour when actually at work, and the cost of the power at two cents for the same unit against 1½ cents for the gas engine.

This is considered as the beginning of a movement in the direction of cheap gas that is likely to spread, and if so, its influence as a means of power distribution will be powerful. At these rates, power may be had in Boston for manufacturing purposes at an advantage over steam, or over electricity when produced by steam.

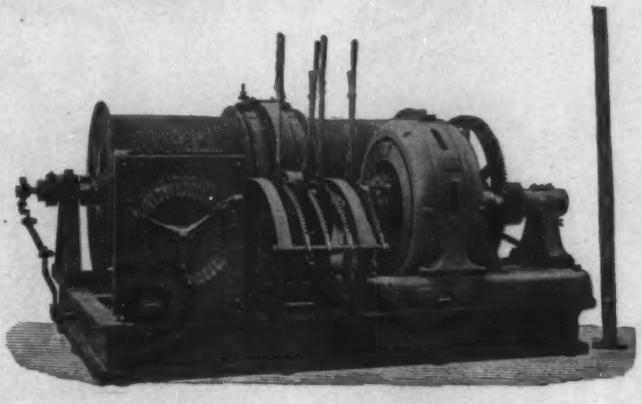
*Abstract from the *American Gas Light Journal*, page 152, January 30, 1899.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

DOUBLE DRUM HOIST AND ELECTRIC MOTOR.

HERE is illustrated an electric hoist which shows one of the recent applications of a General Electric induction motor to a double independent drum mine hoist. It is compact in form, and the levers controlling the clutches and brakes and handle of rheostat are placed in the position most convenient



for control by the operator standing on a platform above the floor and having a clear view over the top of the hoist.

Each friction drum is driven through a single reduction gearing by a 100-volt, 12-pole induction motor of 30 horse-power capacity, running at 600 revolutions per minute. Each drum is independent, and is 42 inches in diameter by 40 inches face. Together they hold about 420 feet of ⅞-inch rope. The maximum hoisting speed is 300 feet per minute, and the weight hoisted, *i. e.*: the load, car, and cage, is 2100 pounds. The depth from which the load is to be hoisted is 400 feet from the surface.

HIGH AND LOW FREQUENCY ALTERNATORS.

FOR alternating current electric plants in which lights alone are to be considered, with high potential distribution, high periodicity generating apparatus is desirable both from simplicity and low first cost. When, however, long distance transmission enters as an important factor, a periodicity of 60 cycles, on account of diminished reactive drop in the lines, allows of transmission over a greater distance than by a high periodicity.

The General Electric Company, manufactures alternators of 60 and 125 cycles frequency in both revolving armature and revolving field types. Revolving armature machines of 125 cycles frequency are built in five standard sizes, 30, 60, 90, 120, and 180 kilowatts, each size wound for 1040 or 2080 volts. The low periodicity alternators are wound for 1040, 2080, or 3120 volts and are built in capacities of 60, 90, 120, and 180 kilowatts. All are arranged for belt driving and are set on rails.

The fields are both separately and self-excited, part of the main current being rectified for the self-excitation. The current for the separate excitation of the fields is derived from a small direct current generator driven by belt from a pulley on the end of the armature shaft. The two windings allow of adjustment of the fields to automatically compensate for changes of load, thus giving a practically constant potential at the terminals. The machine may also be over-compounded to compensate for line loss.

The degree of compounding is regulated by a shunt mounted against the inside of the pillow block at the collector end. It is properly adjusted when the machine is under test at the factory.

The magnetic field includes part of the frame which is a cast iron ring with inwardly projecting poles of laminated iron. By this means eddy current losses are reduced and the reluctance of the magnetic circuit diminished. Both separate and series field coils are wound upon removable spools, the winding of double covered copper wire being carefully insulated from the spools themselves.

The armature is iron clad; laminations of soft steel built up on a cast iron spider form the core, and each shunt is carefully japanned before assembly, while to guard against eddy currents thin paper sheets are interposed between adjoining plates at frequent intervals. The core is thoroughly ventilated by air drawn through the spider and circulating in the ventilating spaces between core and windings. The coils are wound on forms and thoroughly taped and insulated before they are placed in the core, in which they are secured by insulating blocks. They are supported at the end by saddles of light metal which give ample support to avoid injury by centrifugal force. This method allows of ready removal of any coil when necessary.

Commutators and collectors are of copper of the highest conductivity, and are mounted on a metal hub keyed to the shaft. The insulation consists of mica and hard rubber so arranged that short circuits and grounds are practically impossible. The collector brush holders are supported on a cast iron standard and insulated from it by hard rubber bushings. The commutator brush holders are supported on a yoke carried by the adjoining pillow block. The bearings are spherical and self-oiling, self-centering, and self-aligning, and of ample length to ensure cool running.

Each alternator, before shipment, is subjected to most thorough tests. The insulation of the separately excited field coils is tested to 3000 volts alternating, and the series coils and armatures at pressures at least double the normal operating voltage.

AN OPPORTUNITY FOR PRUDENTIAL INVESTMENT.

AGAINST gold mining there is no combination of men or capital. In league with gold mining are not only the miners, rich and poor, but the trusts, the corporations, and the governments of the old world and the new world. The peoples of the whole earth are the patrons of this industry, and legislate in its favor. Gold always finds a market and always sells at par. Instead of the old adage, "as good as wheat," is now heard "as good as gold." While values of real estate vary with the seasons, and the products of the soil are ever changing with new conditions, gold, like the laws of the Medes and Persians, changes not. Gold belongs to him who finds it, and there is no respecter of persons. Our commercial cities may decay, agricultural communities may languish, but California's mining regions are prosperous to a degree hardly known since the Argonauts of '49 crossed the plains. The certainty of its value and the modern methods of mining have eliminated its former speculative features and have made this the most popular industry in the Golden State. Since General Sutter, in 1848, made that wonderful discovery in the mill race, California has produced $1,250,000,000 of gold; from 1850 to 1862 an average of $55,000,000 annually, and in the year of 1897 about $17,000,000. In the one county of Tuolumne, hereafter particularly referred to, there was produced last year of the yellow metal nearly $2,000,000.

In view of the foregoing, and other reasons, a company has been organized to develop three exceedingly promising mines, the Dewey, Sampson, and Schley, located in one of the best mining regions in the world. The public generally is invited to consider well the merits of the business proposition presented below, as the opinion is held that an unusual opportunity is offered for an investment.

The Dewey, Sampson and Schley mines are located on the Tuolumne river, five miles northeast of Groveland, Tuolumne county, which is recognized as the second greatest bullion producing county in California. Of the $1,250,000,000 taken from the placer mines of this state, Tuolumne has contributed $215,000,000, or about one-sixth of the whole amount.

These mines are on the same ledge as the Buchanan and Kanaka, the former being one mile north, having a bullion record of $600,000; the latter being one and one-half miles south, a dividend-paying mine owned by Fresno capitalists.

These three mines each consist of 1500 feet long by 600 feet wide; in all 4500 linear feet on the ledge. The croppings are prominent the full length of the three claims. The vein is a true fissure, and the hanging and foot walls are each of slate. Commencing near the water's edge there is a tunnel fifty feet long; at an elevation of twenty feet above this tunnel is another tunnel fifty feet long, each tunnel being five feet wide and seven feet high. There has also been some surface prospecting at various points on the ledge to determine its value, but it is not of a permanent character. The ledge is six feet wide from wall to wall, and is all milling ore.

These mines were first located in 1873; in fact nearly all of the development work on them was done over thirty years ago. At that time there was on the property a five stamp mill, which later on was burned down. In 1885 B. A. Ogden built an arastra on the property and worked considerable ore from one of these mines. Over his signature he states that the average yield of the ore worked was $11.00 per ton. From the first discovery of these mines the ground has been considered valuable, and since the development of other rich mines on the same ledge and in the immediate vicinity, this ground has greatly increased in value. The returns show that from about 500 tons of the ore milled in the seventies, the average milling value of the ore at that time was $6.25 per ton. As there were in the mine at that time no inclines, cross-cuts, or stopes, the ore milled was taken wholly from the two tunnels referred to. Also at this early date, the sulphurets were regarded as waste, but now the sulphurets, by the modern process of working, yield from $300 to $400 per ton. It is a conservative estimate that $6.25 per ton is the average value of this ledge. The character of the ore is free gold and sulphurets, the latter being valued at from $300 to $400 per ton. The ore is free milling and easily worked.

The proposed permanent tunnel, through which the mines will be worked, is just avove the water's edge of the Tuolumne River. Abundant water power for the mill is practically on the mill site. Also, within 100 yards of the mouth of the tunnel is a splendid location for an electric plant, to be run by free water power. By running on the ledge the amount of stoping ground gradually increases, as progress is made in the tunnel, until at a point 700 feet from its beginning, where there will then be 2600 feet of backs—that is to say, the end of the tunnel will be 2600 feet beneath the apex of the hill. Having reached this point, this will be, with two exceptions, the deepest mine in California. The ore will be run on cars from the mine to the mill, thus avoiding all expense of hoisting, and at the same time the tunnel will be used for draining the mine of water, thus obviating the expense of pumping.

With these facilities, which are unsurpassed anywhere else in California, the cost of mining and milling the ore will not exceed $1.25 per ton; $6.25 ore would, therefore, yield a net profit to the company of $5 00 per ton. Working sixty tons per day there would be a net profit of $300 per day, or $9000 per month. The estimated cost of running the tunnel, five feet wide and seven feet high, is $5.00 per linear foot. Having run the tunnel 400 feet, there should be plenty of milling ore for a 20-stamp mill. This work would cost $2000. A 20-stamp mill would cost about $15,000. By an expenditure thus of about $17,000, this group of mines should be handsomely dividend paying.

The company is incorporated for $250,000—250,000 shares of stock at $1.00 per share. Of these 120,000 shares have been disposed of in the purchase of the property. The remaining 130,000 shares, which is a majority, is treasury stock. This is to be sold, the proceeds to go towards the development of the mines and the purchase of a mill. The stock first sold will be at par. The price of the stock later on will depend upon the developments in the properties, and may be advanced at any time by the board of directors. The stock sold at $1.00 per share will be on terms as follows: Five cents per share at the time of executing the contract, and five cents per month thereafter until the amount of $1.00 per share shall have been fully paid. Each share of stock represents a pro rata interest not in an option or bond, but an interest in the property itself.

Under a guarantee of the company, all stock is non-assessable. The board of directors agree with every purchaser of the stock that the mines will be kept free from debt; that no expense of any kind shall be incurred beyond the limit of the funds on hand; that, in short, under no circumstances, will there ever be an assessment levied on the stock for any purpose whatever. As this is a provision of the by-laws the board of directors are individually and collectively held liable to the stockholders for any violation of this agreement made with each and every stockholder. The company owns the titles to the mines. The title is perfect and the property is free of incumbrance.

These mines are owned by The East Belt Gold Mining Company, the San Francisco office of which is at 602 Market street. Of the personnel of its board of directors, the president, Hon. C. S. Young, is ex-State Mineralogist of Nevada, and more recently the right of way agent of the S. F. & S. J. R. R. Company. The vice-president is John Moss, Esq., traffic manager of the S. F. & S. J. R. R. Company, now a part of the Santa Fé R. R. Company, 321 Market street, San Francisco. The secretary is H. S. Allen, Esq., a mining man of state reputation, who resides at the Grand Hotel, San Francisco. The treasurer is E. P. Barrett, who is ex-member of the San Francisco Board of Education, and now a member of the San Francisco Stock and Exchange Board, and of the firm of J. S. Barrett & Co., stock brokers, 327 Pine street, San Francisco. Director George Beaudet is of the wholesale firm of Daveluy & Co., Sonora, Cal.

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